CURRENT CHANGES OF THE POPULATION STRUCTURE AND SPECIES COMPOSITION

It is quite natural, that in the course of time the structure of fauna and species composition may change. Reasons might be numerous and introduction (casual or artificial) is only one of them. This implies that diverse biological consequences of natural or artificial substitution of vanishing or weak elements of marine ecosystems deserve special consideration. These continuous processes affect all trophic levels from whales, walruses, dolphins to various species of plankton. First of all we have to consider such processes as

- quantitative outbursts of scarce species
- unintentional introduction of alien species (alien invasion)
- planned introduction of species typical for other seas (introduction).

QUANTITATIVE OUTBURSTS OF SCARCE SPECIES

Processes in the Black and Azov seas basin give a good idea of the nature of the process (**Fig.** 37). Bream, zander and silver porgy (*Carassius auratus gibelio*) are the three most important marketable fishes of the Azov basin. The share of silver porgy in the yield pattern over the period from 1983 to 1994, by Azovrybvod, increased from 1.7% to 30.7%, in 1996 this figure was 20.8%. Annual catch of this species varied from 100 to 1,500 t (Abramenko 1998). In some cases catches amounted to 50 t per one deployment of gear.

There is a number of interdependent and interacting variables that explain this phenomena of outburst, stabilization of abundance at the high level and expansion of silver porgy. Initially this species migrated to the Azov Sea from the ponds into which it had been introduced by aquafarmers.

Alteration of hydrological and hydrochemical cycle of ecosystems in the Azov-Don and the Azov-Kuban basins in the 1950–1970s led to transformation of genetic structure of porgy population in the estuaries of the Don and Kuban rivers from unisexual-bisexual structure to predominating bisexual structure. A unisexual gynogenetic model using male sperm of closely related valuable species of Cyprinidae family (carp, bream, sea-roach) for reproduction was absolutely dominating until the end of the 1970s (Abramenko and Kravtchenko 1998). Later the mouth and the estuarine part of the Don River became a home base for expansion of this unpretentious fish in two directions characterized by formation of river, pond and sea populations.

The trend of previously scarce species became clearly distinct in the Barents Sea in the 1980–90s (**Fig.** 37). Populations of *Hyperiid amphipods*, medusas (common jellyfish, *Cyanea arctica*), ctenophora, squids, pearlsides (bathypelagic fish moving in shoals) became very prominent in the ecosystem.

Common jellyfish biomass in the Black Sea over last 30 years increased from 1.38 to 12 g/m^3 , its wet weight grew from 670,000 t to 500–600 mln t (it is 300 times as much as the total biomass of all fishes of the sea), occurrence in catches made by trawls with small mesh (meant for adolescent fish) comprises 21 to 89 %. The north-west population of the Black Sea medusa in the middle of the 80s (over 40 mln t) was consuming up to 62% of diurnal forage zooplankton

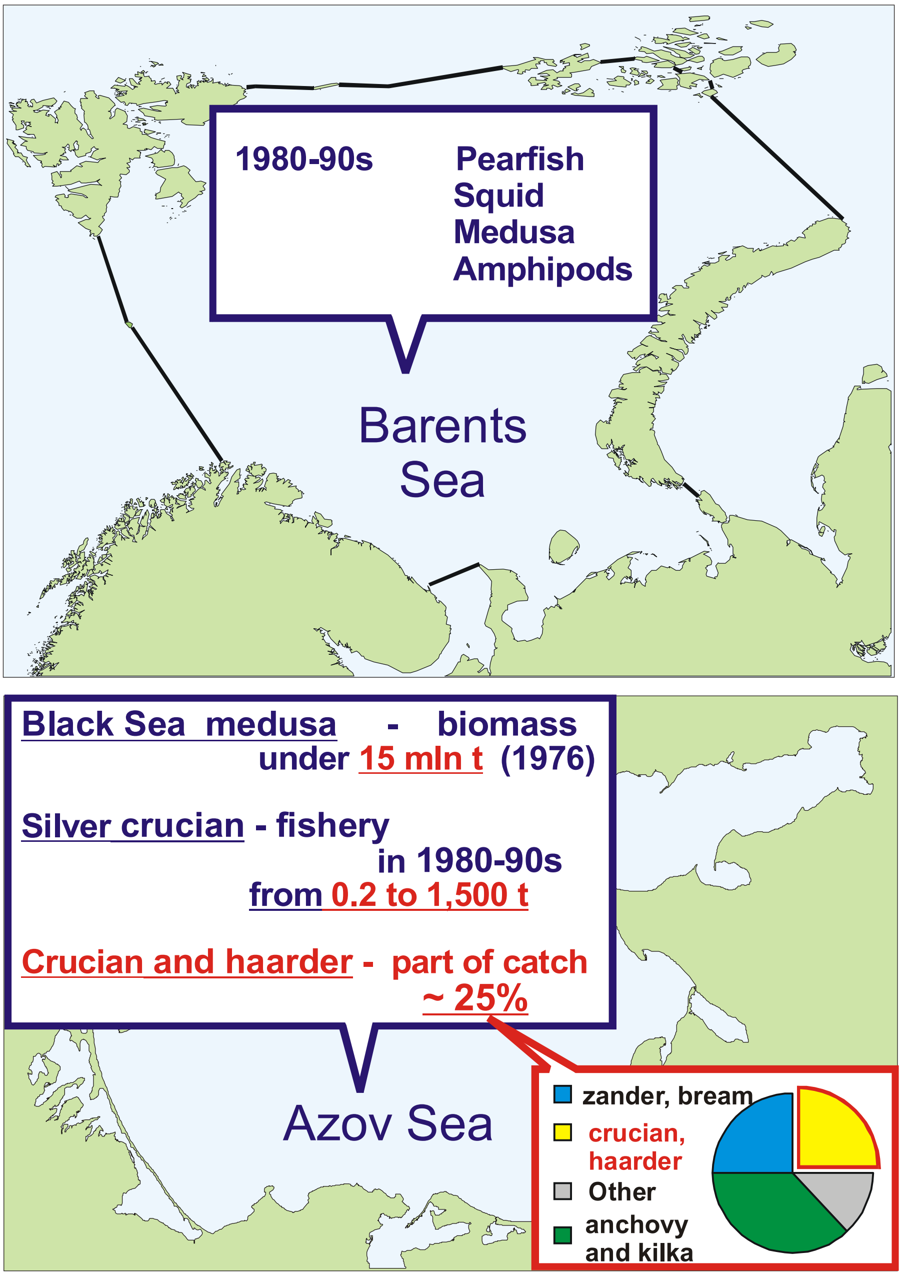


Fig. 37. The outbursts of scarce species in the Barents Sea and Azov Sea (by Timofeev 1996, Abramova 1998, Volovik et al.)

production of the sea on the whole and up to 5–7% of its biomass (Gomoyou and Kuprijanova 1980, Zaitsev and Polyshchuk 1984, Flynt et al. 1989).

Increase of the Azov Sea salinity level in the 1970s triggered reproduction of medusa originating from the Black Sea, which started competition with fishes for zooplankton (**Fig.** 38). In 1976, this population had wet weight of 15 mln t. All this huge medusa biomass was «contaminating» the sea as it was not grazed upon by other hydrobionts.

Year	Medusa	Ctenophora	Year	Medusa	Ctenophora
1974	1.98	-	1986	0.07	-
1975	3.60	-	1987	0.04	-
1976	15.5	-	1988	0.4	0.04
1977	7.3	-	1989	single	32.0
1978	7.0	-	1990	single	20.0
1979	5.9	-	1991	single	30.2
1980	3.9	-	1992	single	15.1
1981	0.4	-	1993	single	21.4
1982	0.3	-	1994	single	21.1
1983	0.23	-	1995	single	18.7
1984	0.013	-	1996	single	22.0
1985	0.10	-			

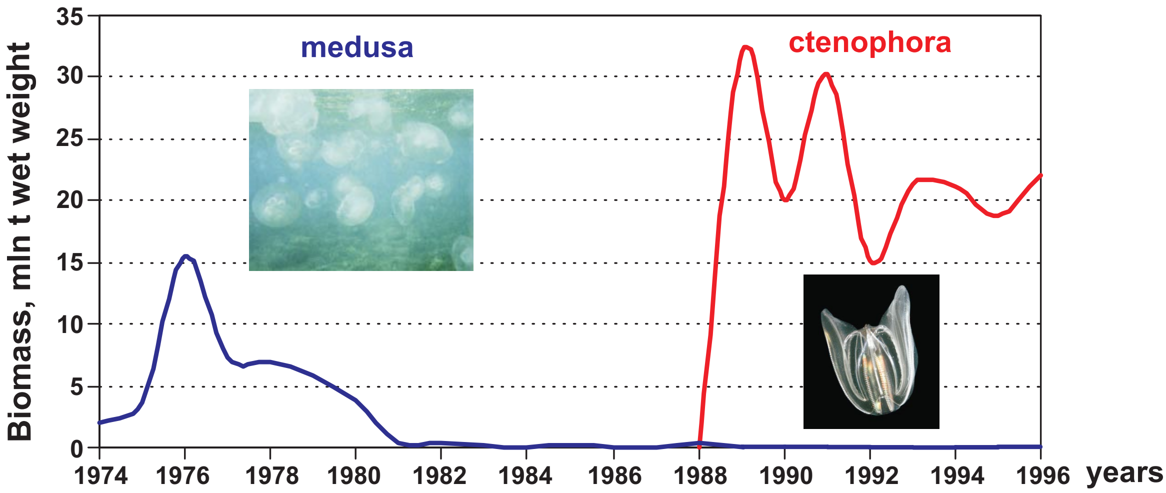


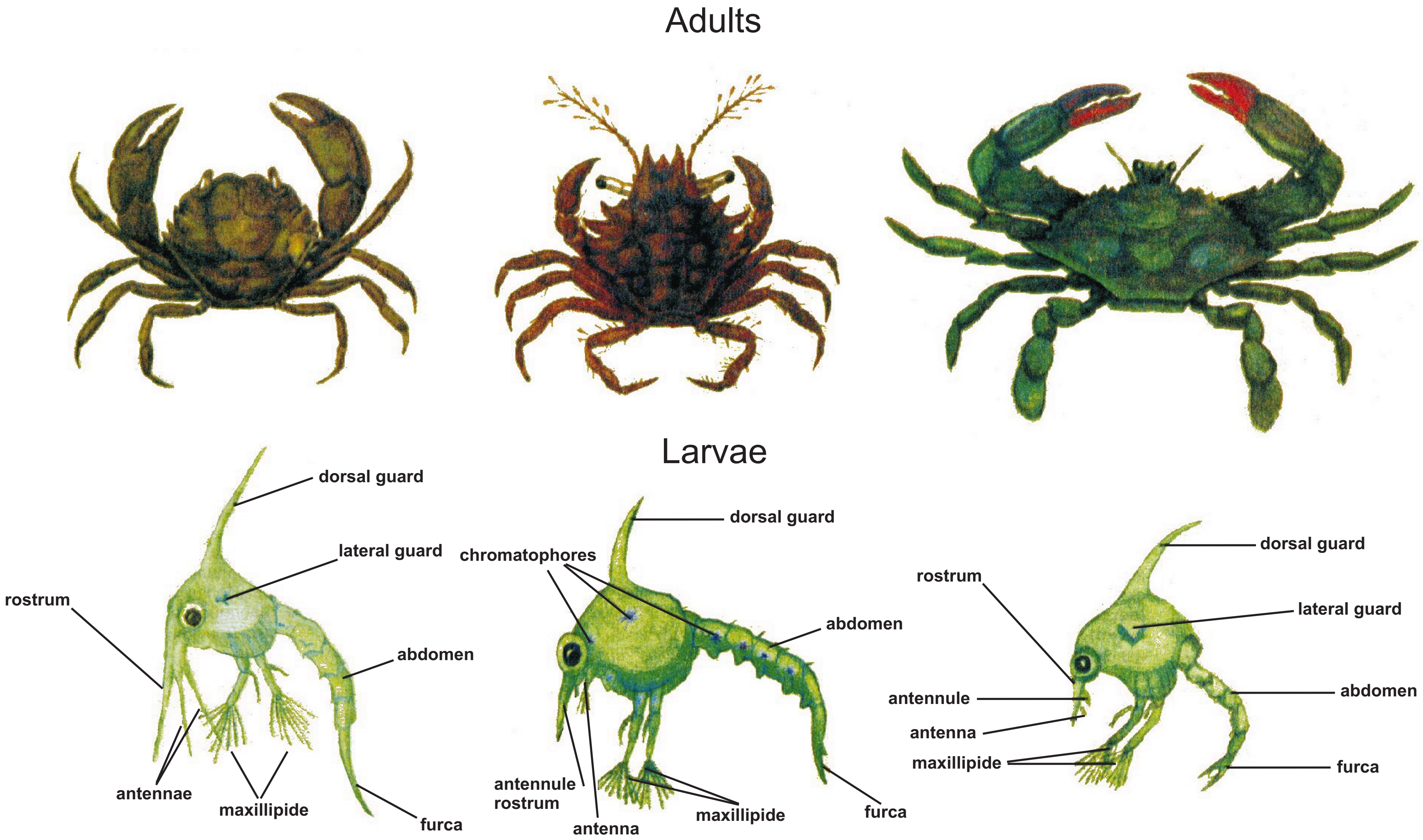
Fig. 38. Dynamics of jelly fish and comb-jelly biomass in the Azov Sea (by Volovik et al. 1998)

UNINTENTIONAL INTRODUCTION OF ALIEN SPECIES

The problem of introduction of alien species is characteristic of many seas of the World Ocean. Alien species invasion often causes repression of local competitors for food, leads to huge quantitative outbursts both resulting in incalculable economic losses.

The Black Sea

It is worthwhile to mention three of the casual migrants, crabs *Brachyr* (**Fig.** 39): *Rhithropanopeus harrisii tridentatus*, *Callinectes* and *Sirpus zariquieyi* (Makarov and Murina 1998). *Rhithropanopeus harrisii tridentatus*, a subspecies of American crab (*R. Harrisii*), lives in fresh and brackish waters of the coastal area of the American continent. This crab was traced in the basin of the Black Sea first in the Dnieper and the Don rivers estuaries in 1939 and 1952 respectively. In the course of several years its population expanded to the Azov Sea. This subspecies also migrated to the Caspian Sea via the Volga-Don canal and occupied all vacant positions of upper sublittoral ecosystem.



On the left to the right: the males of holland crab and sirpus, adult female of blue crab

Fig. 39. Crabs introduced to the Black Sea (by Makarov Yu.N., Murina V.V.)

Blue crab is a migrant from the Atlantic coastline area, too. It is very resistant to freshening of water and is often found in estuaries and lagoons, though it can also live in waters with high salinity. Despite its relatively small number in the Black Sea as compared to *Rhithropanopeus harrisii tridentatus*, it has inhabited much vaster area up to the coastline of the Caucasus. Introduction of the above mentioned crabs might have been facilitated by vessels carrying ballast waters containing larvae.

Alien species invasion has become an extremely dangerous phenomenon (**Fig.** 38). One example is introduction of comb jelly in the 1980s (*Mnemiopsis leidyi*), which was brought to the basins of the Black and Azov seas from the eastern coast of the North America with ballast waters (Vinogradov et al. 1989). Outburst of comb jelly in the Black Sea caused decrease in stocks of sardelle, anchovy and some other marketable fishes both as competitor for food and as predator grazing upon their larvae (Volovik et al. 1991). By the end of the 1980s, its biomass approached 1 billion tons (Zaitsev 1998). Ecological influence of *Mnemiopsis leidyi* on marine biota is determined by its enormous abundance of 10–12 kg/m^3 (Vinogradov et al. 1989). During the period of intensive development its diurnal consumption rate is 7% of actual biomass and over 50% of diurnal zooplankton production.

Mnemiopsis leidyi are both food competitor of fishes grazing on plankton and their immediate predator. This is the explanation of sharp decrease in zooplankton and ichthyoplankton biomass which fishes were grazing upon at the end of the 1980s. During 1989–1990 yields of the Black Sea most popular marketable fish, anchovy, reduced dramatically. At that period, yields of fisheries based in the Black Sea states fell from 650,000 to 90,000 t (Zaitsev et al. 1998).

The Azov Sea

Copepods were dominating zooplankton communities before *Mnemiopsis leidyi* invasion in the Azov Sea (55% of biomass). Rotifiers, cladocerans, temporary plankters comprised only 15–27% of total biomass (**Fig.** 38). As practically all groups of the Azov Sea plankton were food objects for *Mnemiopsis leidyi*, zooplankton community species, age and trophic structures were altered dramatically (Volovik et al. 1997). *Mnemiopsis leidyi* competes with mass pelagic fishes (sardelle and anchovy) for forage by using 80% of zooplankton production. The remaining biomass of forage zooplankton in summer time comprised before the invasion of *Mnemiopsis leidyi* 250–300 mg/m^3 and decreased recently by several orders of magnitude (Lutz et al. 1997). *Mnemiopsis leidyi* increase rapidly (in 1–2 months) during spring and the beginning of summer annually developing gigantic biomass (15–30 mln t of wet weight) (Volovik et al. 1996). *Mnemiopsis leidyi* invasion related losses of sardelle and anchovy yields in the Azov Sea estimated as 100,000–110,000 t annually. Thus introduction of only one new ecosystem element caused changes not only on the local, but on the regional level of the Azov-Black sea basin and altered the system lifecycle.

The Azov Sea ecosystem is dominated by bivalve mollusks. Associations of *Cerastoderma* and *Arba* are main components of benthos communities. They take a really important part in the cycle of matter as main food objects for sturgeon and other benthophages. Numerous newcomers from ocean basins participate in forming shelf associations of *Bivalvia*, which is the case with bivalve mollusk *Anadara sp.* invasion to the Azov Sea (Tchikhatchev et al. 1998). Colonies of *Anadara* in the south of the Azov Sea are connected with biocenosis of *Cerastoderma* *lamarcki* and *Abra ovata*. Over the short period 1989–1992, its average biomass grew from 0.5 g/m^2 to 4.2 g/m^2, and in some areas its density equaled to 32–198 g/m^2 with number up to 10 specimens per 1 m^2. It is obvious, that depth 10–11 m, salinity 10.2–12 ‰, oozy bottom with inclusions of sand or gapers are favorable for expansion of these mollusks.

Stone morocco originating from Far East rivers can be regarded as the case of alien species introduction. The fish was brought to aquafarms of the Don River basin as a result of poor control at the transportation stage over introduction of silver carp, white and black amur. According to *Azov Fishery scientific-research institute* data silver carp became wide spread by the end of the 1980s and nowadays it is observed in Taganrog Bay (Nadtoka and Abramenko 1998). The danger of introduction of this fish is in its facultative parasitism, which finds its manifestation in grazing upon dermal and muscle tissues of commercial silver carps, bream and zander juveniles.

As active planktivore it may become a dangerous competitor for juveniles of carp family during its lifecycle occupying the same positions of biotope in natural reservoirs. Statistical analysis of the data has proven alimentary preference of stone morocco towards larvae of carp family and porgy family. Formation of stable stone morocco populations under favorable conditions of Taganrog Bay may become a prelude to its undesirable penetration to reservoirs of Azov-Don and Azov-Kuban basins.

The Caspian Sea

The danger of *Mnemiopsis leidyi* penetration into the Caspian Sea is present as ships are a good medium of fauna and flora exchange via Volga-Don canal. This is the case of diatomaceous algae *Ectocarpus caspicus* (Caspian endemic) invasion into the Black Sea and vice versa penetration of *Rhizosolenia calcaravis* from the Black Sea into the Caspian Sea where this species became dominant.

Nearly all species introduced to the Caspian Sea are characterized by outbursts of abundance in the years immediately following their settling down. Thus *Rhizosolenia calcaravis* in several years after appearance comprised $^3/_4$ of total plankton biomass and balanus comprised 2 mln t. The outbursts were followed by decrease in aliens number and consequent stabilization of their abundance. Nevertheless, invaders are dominant and the most abundant populations in the Caspian Sea (Zenkevitch and Zevina 1969). Phytoplankton is dominated by *Rhizosolenia calcaravis*, which often comprises more than 50% of its total biomass. Zooplankton is presented mostly by medusa *Blakfordia* and to a greater degree by larvae of *Balanus*, *Mitilaster*, *Syndesmia*, *Nereisa*. It is possible to point out that alien biomass exceeds aborigine biomass. Occasionally introduced buffalo occupied the ecological niche formerly occupied by bream, zander and other benthophages in the Volga river delta.

The Baltic Sea

A representative of Caspian zooplankton the predatory *Cercopagis penqoi* has been increasingly frequently detected in the Bay of Finland of the Baltic Sea beginning from 1992. The reason for this appearance is transfer of eggs resistant to unfavorable environment with ballast waters of vessels (Avinsky 1997). Concentration of this small animal (approximately 1 cm) may reach 300 specimen per m^3 . *Cercopagis penqoi* heavily competes with planktivore for food while it is inedible for fish owing to peculiarities of its morphological structure. The increase of *Cercopagis penqoi* trend leaves little chance to avoid consequences similar to that caused by invasion of the Black Sea by *Mnemiopsis leidyi*. This kind of situation may be expected in other seas of Russia.

The Barents Sea

In May and November of 1996, crab *Chionnoecetes opilio* was first detected in the south-east of the Barents Sea close to Gusinaya bank. This marketable species is wide spread in North Atlantic and North Pacific water areas at depth of 20–500 m. Casual drift of larvae or their transportation with ballast waters is supposed to be one of the possible ways of introduction of *Mnemiopsis leidyi* to the Barents Sea shelf (Kuzmin et al. 1998).

Descriptions of a number of exotic representatives of plankton, benthos and fish are given above. However newcomers are found among ornitofauna as well. According to observations of Kandalaksha State Reserve (Y.V. Krasnov, personal message), two new species of seabirds (gannet, great skua) settled in the Barents Sea region since the end of the 1940s (**Fig.** 40).These birds started colonization of islands and coastlines of Murman in the 1980–90s. The studies proved that colonies comprised birds migrated from Mid Atlantic areas where their food basis had been completely altered by heavy fishing. Increase in fishery waste and decrease in abundance of predatory fishes, alongside with stock growth of such marketable fish of secondary importance as gerbil, facilitated outburst of gannet and great skua populations. After that these birds started formation of new colonies along the Kola peninsula coast.

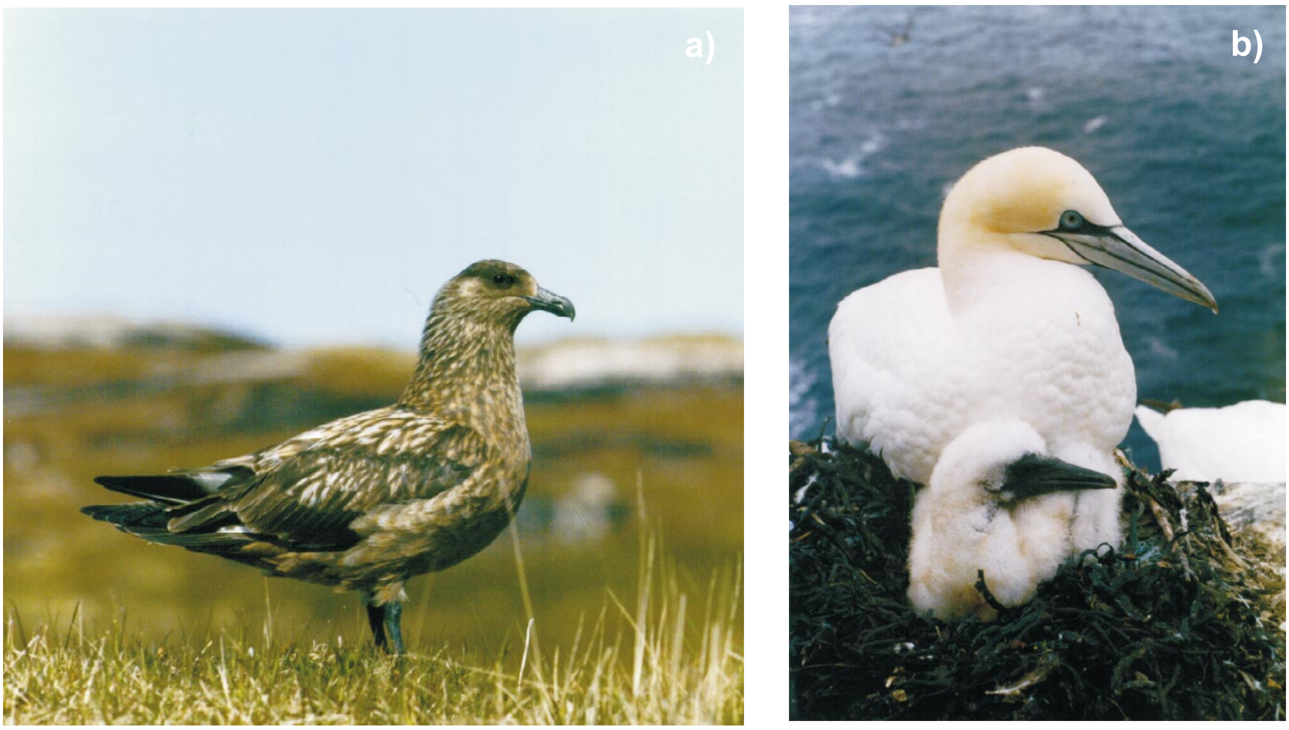


Fig. 40. The North Atlantic introducers into the Barents Sea (Photo by doctor of biological sciences Yu. N. Krasnov) a) great skua;b) garnet

PLANNED INTRODUCTION OF NEW SPECIES FROM OTHER AREAS

It is no accident that new marketable species of fauna from Far East and North America in the 1950–80s were introduced to balance the decrease of bioproductivity in the above mentioned marine ecosystems. 5–12 species were subject to introduction depending on the basin. Commercial and ecological consequences of these demanding and ambitious projects are disputable. There are, however, examples of successful acclimatization (**Fig.** 41). King crab has been successfully introduced to the Barents Sea. Its introduction started in 1961 and since then its habitat has extended to the southern coastline of Norway. King crab experimental extraction has already been launched (up to 40,000 specimens annually). King crab stock reproductive capacity in the Barents Sea according to a 1995 estimate comprises 23.7 billion eggs (**Fig.** 42,43). Total and marketable stock of king crab in the Barents Sea in 1997 comprised 510,000 and 426,000 specimens respectively (Kuzmin et al. 1998b).

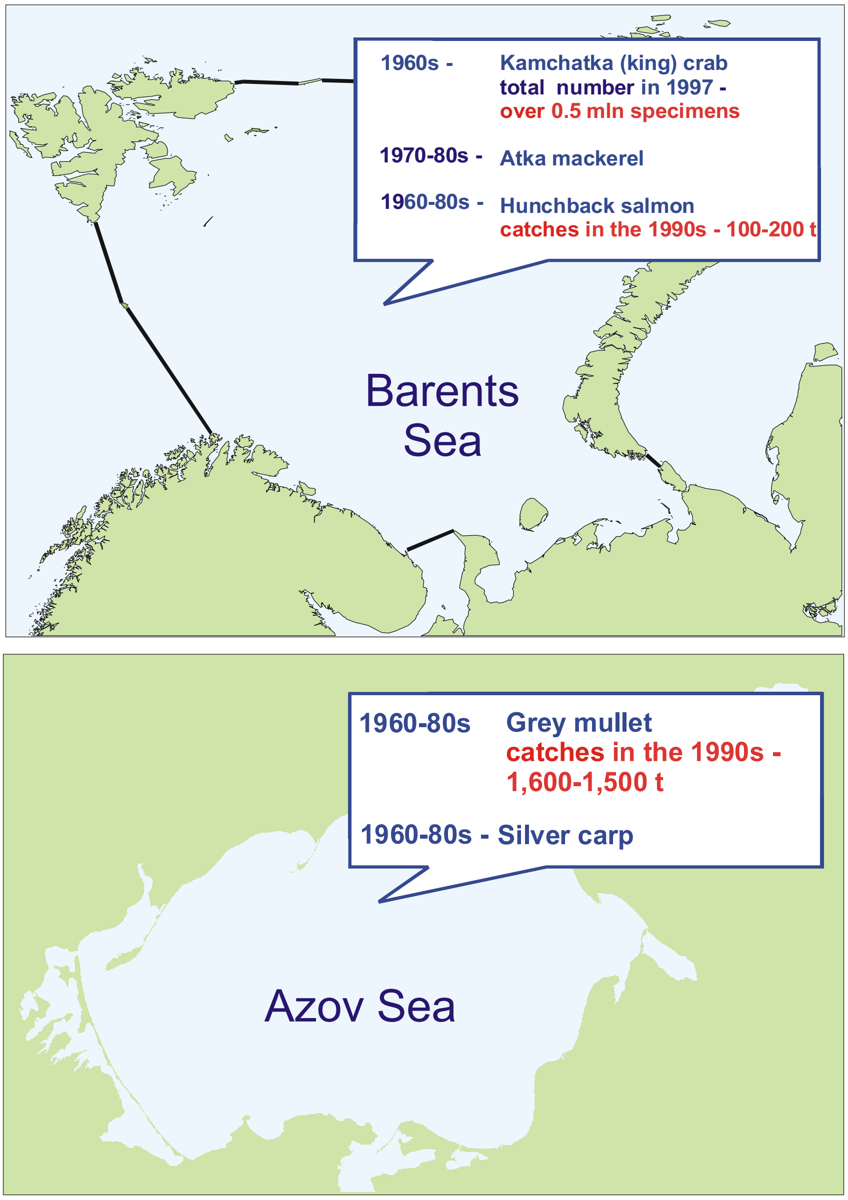


Fig. 41. Introduction of different fauna species

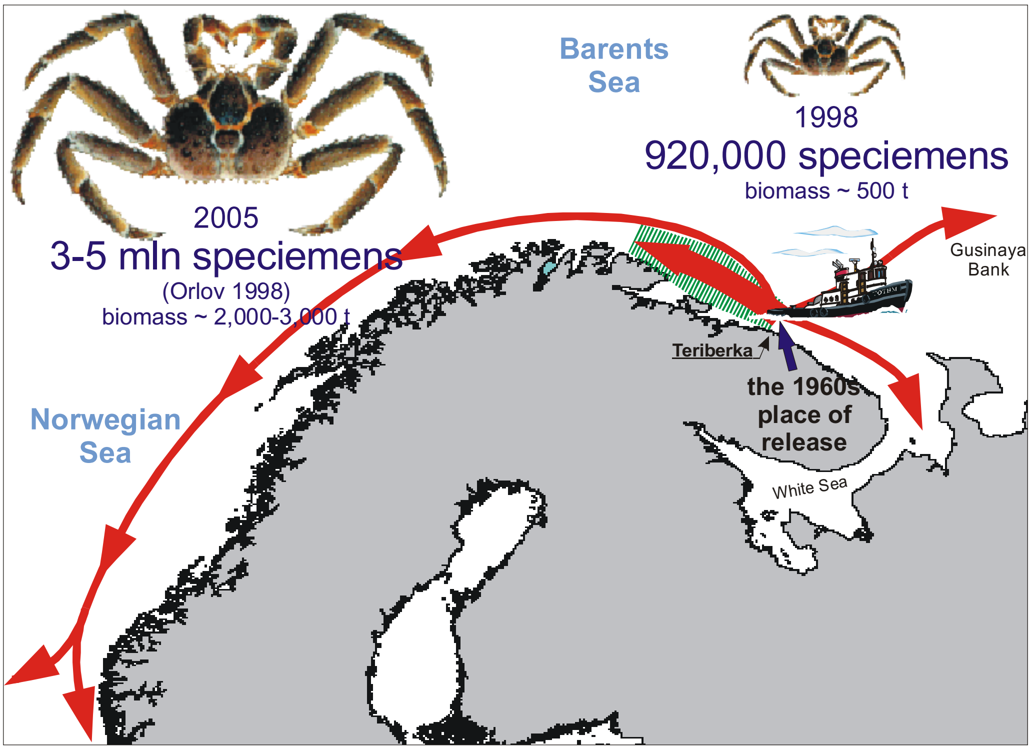


Fig. 42. Settlement of the Kamchatka crab (acclimatized in the Barents Sea) (by the data of PINRO, VNIRO)

Mullets in the Black and Azov seas had lost their commercial value by the 1960s and search for their substitutes began. Nowadays mullets of the Black and the Azov seas are represented by small stocks of local species (gray mullet, golden mullet and leaping gray mullet).

Silver carp and haarder (*Mugil soiuy*) were introduced and successfully acclimatized especially in the estuarine waters of the Azov and Black seas basin. Haarder, recommended for the Southern seas by professor B.N. Kazansky, was successfully acclimatized in the Azov-Black seas basin. The result was a new selfreproducting stock (**Fig.** 43). Haarder produced several generations and now is included into the list of marketable fishes (Volovik et al. 1997). At the moment, the haarder stock is estimated as 40,000–50,000 t. Catches of this mullet recently reached 1,600–3,500 t (Pryakhin 1998). Fisheries experts put the maximum sustainable yield at 10,000–15,000 t.

Despite high abundance of the haarder in the Azov-Black seas basin some biological aspects of its reproduction in the area of introduction remain unrevealed. Fecundity of males and females, duration and parameters of spawning at different sites of the habitat are not yet known. Interrelations of haarder with the aboriginal species of fish and their role in marine ecosystems are still unclear (Gubanov and Serobaba 1997, Pryakhin 1997). Introduction of mullets and haarder into the Azov Sea and introduction of golden mullet into the Caspian Sea caused undesirable competition for food. For example, migrants introduced to the Caspian Sea doubled their growth rate and by 1.5 fold exceed their original size. Some specimens of golden mullet are 70 cm in length.

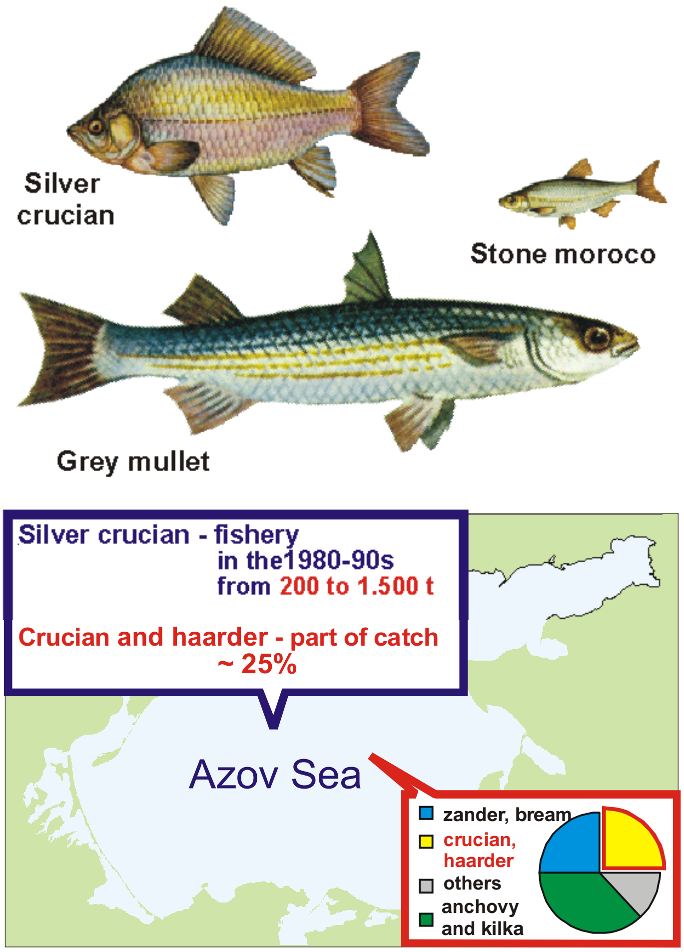


Fig. 43. Expansion of fishes-introducers in the Azov Sea basin (by the data of Volovik 1998, Abramenko et al.1998)

Other cases of introduction are of a more disputable nature. Humpback salmon and greenling did not acclimatize quite well to the conditions of the Barents and the White seas. Transferring of humpback salmon larvae started 40 years ago, but it was only in 1987, after adult fish matured in the sea, when adult fish were detected returning to the spawning areas in the rivers of the White Sea basin. Humpback returning was registered in 1989, 1991, 1993, 1995. These were generations of fish that had spawned in the rivers of the Barents Sea Basin. Yet catches did not exceed 100–200 t per year. The question naturally arises whether there was any biological or commercial reason for introducing humpback salmon. It is so far unclear what ecological niche this fish may occupy and whether it will be competing with salmon for convenient spawning areas (Zhuravleva and Zenzerov 1998).

All above mentioned examples prove fundamental postulates of modern hydrobiology and ecology: ecosystem resources are nearly always being used completely even when the number of species decreases. Also even if biodiversity in most communities is poor, they are saturated by individuals. (Alimov 1998). That is why the thesis that remaining species expand their area using all vacant resources may be said to be true for marine reservoirs. The only question is how useful such changes are from the viewpoint of bioresources.